

PARTICLE POLLUTION

NATURE AND SOURCES

Particle pollution is a general term used for a mixture of solid particles and liquid droplets found in the air. Some particles are large enough to be seen as dust or dirt. Others are so small that they can only be detected with an electron microscope. EPA regulates particle pollution as $PM_{2.5}$ (fine particles) and PM_{10} (all particles 10 micrometers or less in diameter). The PM_{10} discussion follows the $PM_{2.5}$ discussion in this section.

Generally, coarse particles are directly emitted, while fine particles are mostly formed in the atmosphere. Directly emitted particles come from sources such as construction sites, unpaved roads, fields, smokestacks (combustion sources), or fires. Other particles form when gases react in the atmosphere. These are sulfur dioxide (SO_2), nitrogen oxides (NO_x), and volatile organic compounds (VOCs) emitted mostly from power plants, industries, and automobiles; and ammonia (NH_3), mostly from agriculture. Particles formed in the atmosphere make up most of the fine particle pollution in the U.S. The chemical composition of particles depends on location, time of year, and weather. In addition to changes in emissions, weather patterns also contribute to yearly differences in $PM_{2.5}$ concentrations from region to region.

HEALTH AND ENVIRONMENTAL EFFECTS

Particle pollution—especially fine particles—contains microscopic solids or liquid droplets that are so small they can get deep into the lungs and cause serious health problems. Numerous scientific studies have linked particle pollution exposure to a variety of health problems including (1) increases in respiratory symptoms such as irritation of the airways, coughing, or difficulty breathing; (2) decreased lung function; (3) aggravated asthma; (4) development of chronic bronchitis; (5) irregular heartbeat; (6) heart attacks; and (7) premature death. People with heart or lung disease, the elderly, and children are at the highest risk from exposure to particles. In addition to health problems, particle pollution is the major cause of reduced visibility and ecosystem damage in many parts of the U.S., including national parks and wilderness areas.

TRENDS IN $PM_{2.5}$ CONCENTRATIONS

There are two standards for $PM_{2.5}$: an annual standard ($15 \mu g/m^3$) and a daily standard ($35 \mu g/m^3$). The national monitoring network for $PM_{2.5}$ began in 1999 and was fully implemented in 2000. Nationally, annual $PM_{2.5}$ concentrations declined by 14 percent between 2000 and 2006, as shown in Figure 13. Daily $PM_{2.5}$ concentrations have a similar trend with a 15 percent decline.

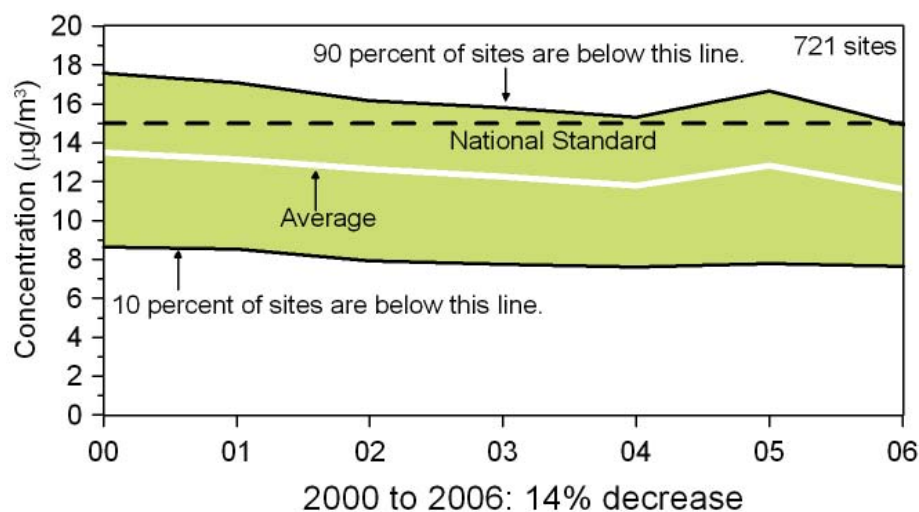


Figure 13. National $PM_{2.5}$ air quality trend, 2000-2006 (annual average).

Note: Roughly 10 percent of sites are still above the standard in 2006.

The national trend for $PM_{2.5}$ shows a steady decline since 2000 with the exception of a temporary increase in 2005, which is discussed on pages 18 and 19.

For each monitoring location, the map in Figure 14 shows whether $PM_{2.5}$ increased, decreased, or stayed about the same between 2000 and 2006. Almost all of the sites show a decline in $PM_{2.5}$ during this period. The areas that showed the greatest improvement were

the ones that had the highest concentrations in 2000, including Southern California. Eight sites showed an increase greater than $1 \mu\text{g}/\text{m}^3$ (Juno and Anchorage, Alaska; Nogales, Ariz.; Klamath Falls, Ore.; New Orleans, La.; El Paso and Houston, Texas; Vilas County, Wis.). Of the eight areas that showed an increase, four were below the level of the annual $PM_{2.5}$ standard for the most recent year of data and four were above. The four areas above were New Orleans, Nogales, El Paso, and Houston.

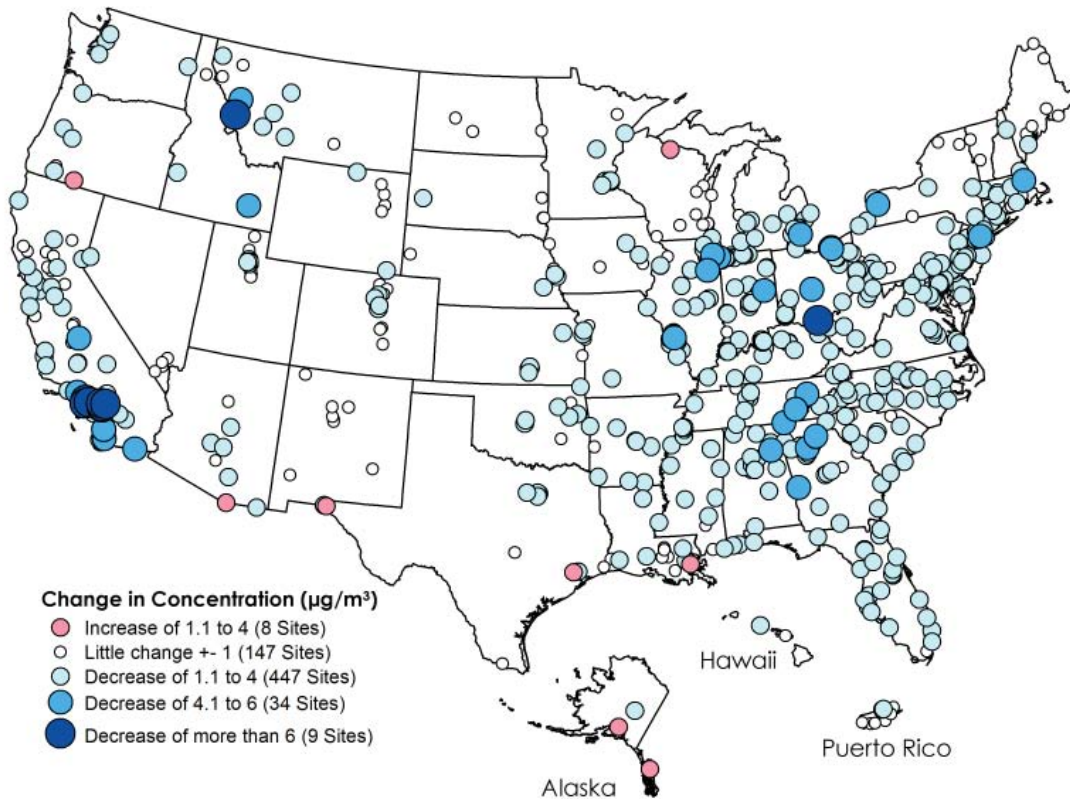


Figure 14. Change in $PM_{2.5}$ concentrations in $\mu\text{g}/\text{m}^3$, 2000 vs. 2006 (annual average).

Note: The national monitoring network for $PM_{2.5}$ began in 1999 and was fully implemented in 2000. Three years of data are used to determine if an area meets the annual $PM_{2.5}$ national standard. The map above shows the difference between individual years.



In 2006, annual and daily $PM_{2.5}$ concentrations were generally the lowest of the seven-year period. As shown in Figure 15, the highest annual $PM_{2.5}$ concentrations were in Alabama, Pennsylvania, and California. The highest daily $PM_{2.5}$ concentrations were in California, Arizona, and Pennsylvania. Some sites had high daily $PM_{2.5}$ concentrations but low annual $PM_{2.5}$ concentrations, and vice versa.

Most of the metropolitan areas displayed in Figure 16 had fewer unhealthy AQI days due to particle pollution in 2006 compared with the average from the previous five years (2001-2005). Los Angeles, Salt Lake City, and Cleveland had the largest decreases in the number of unhealthy days.

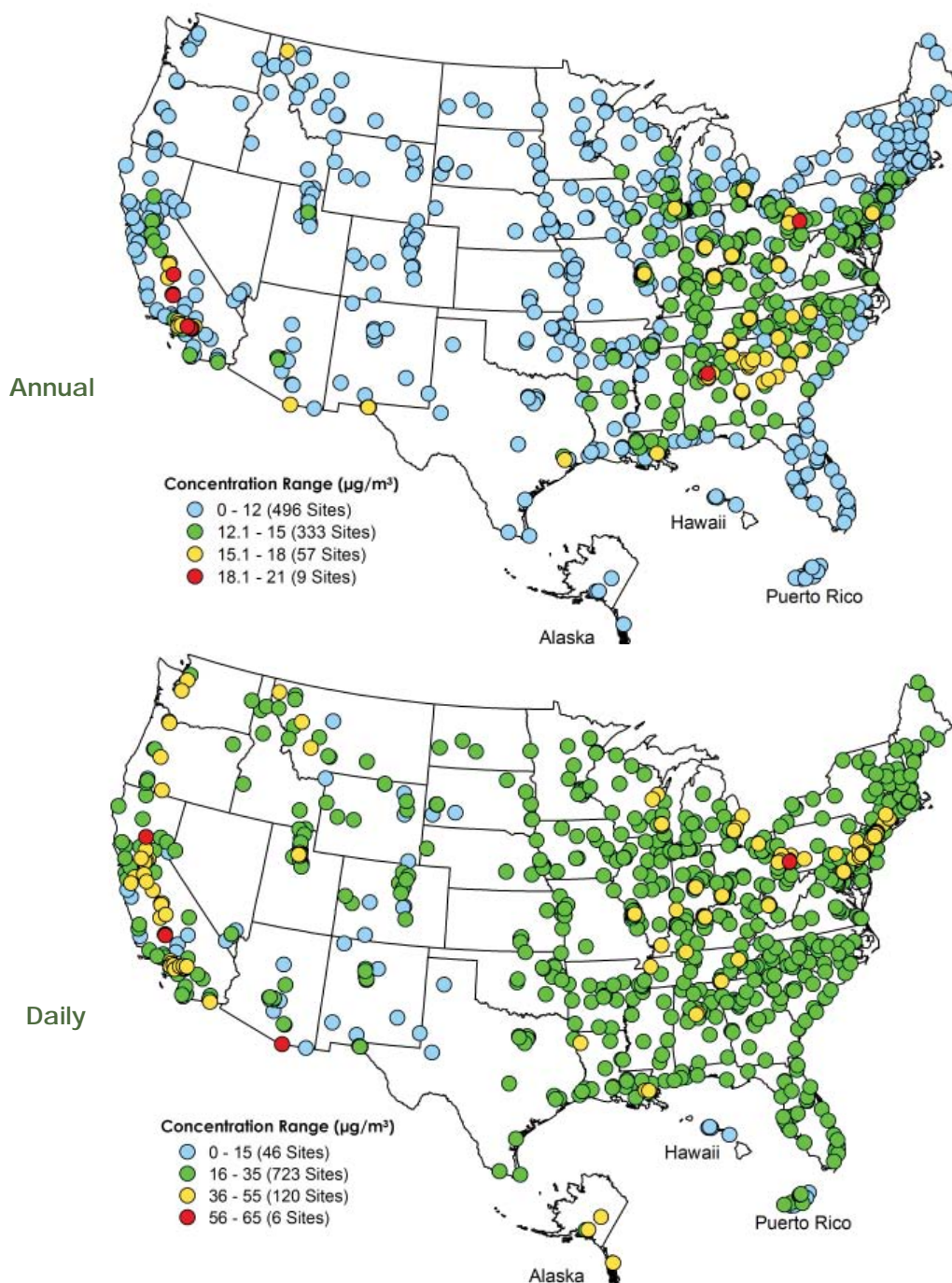


Figure 15. Annual average and daily (98th percentile 24-hour concentrations) $PM_{2.5}$ concentrations in $\mu\text{g}/\text{m}^3$, 2006.

Note: In 2006, EPA revised daily $PM_{2.5}$ standards from 65 to 35 $\mu\text{g}/\text{m}^3$.

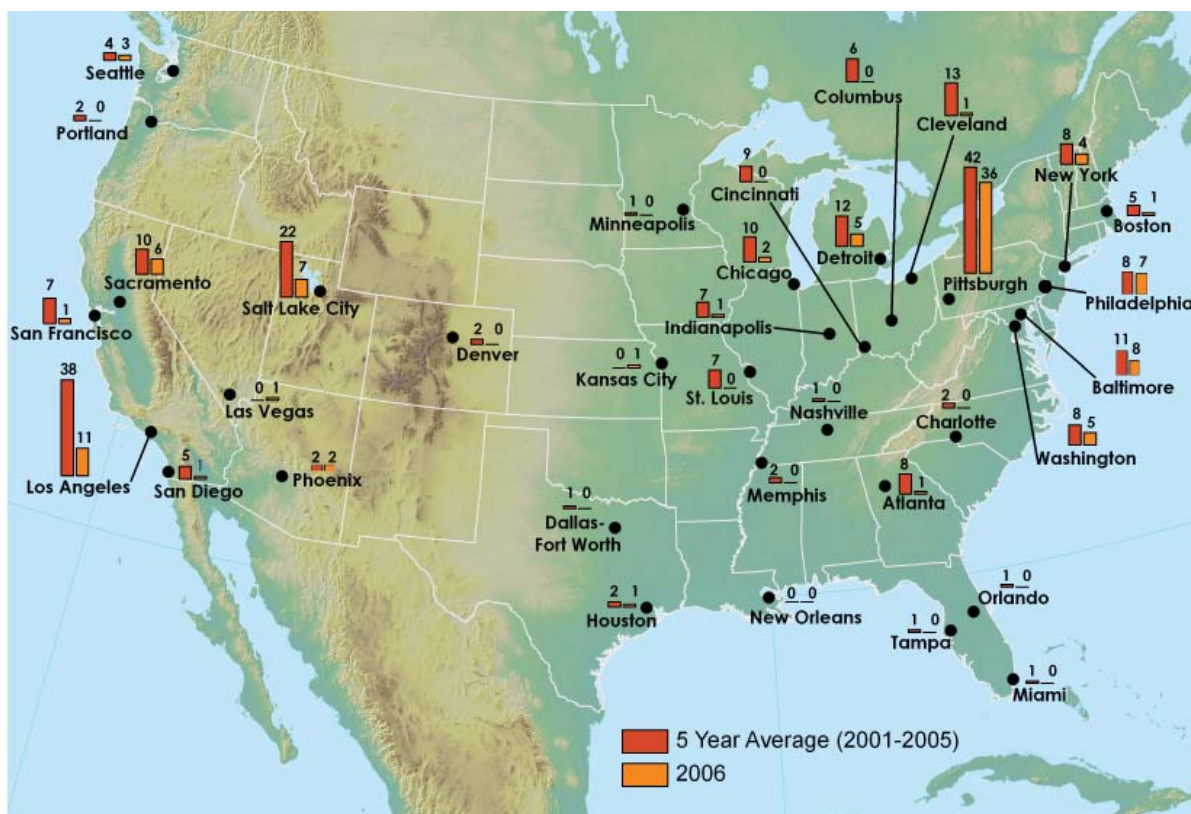
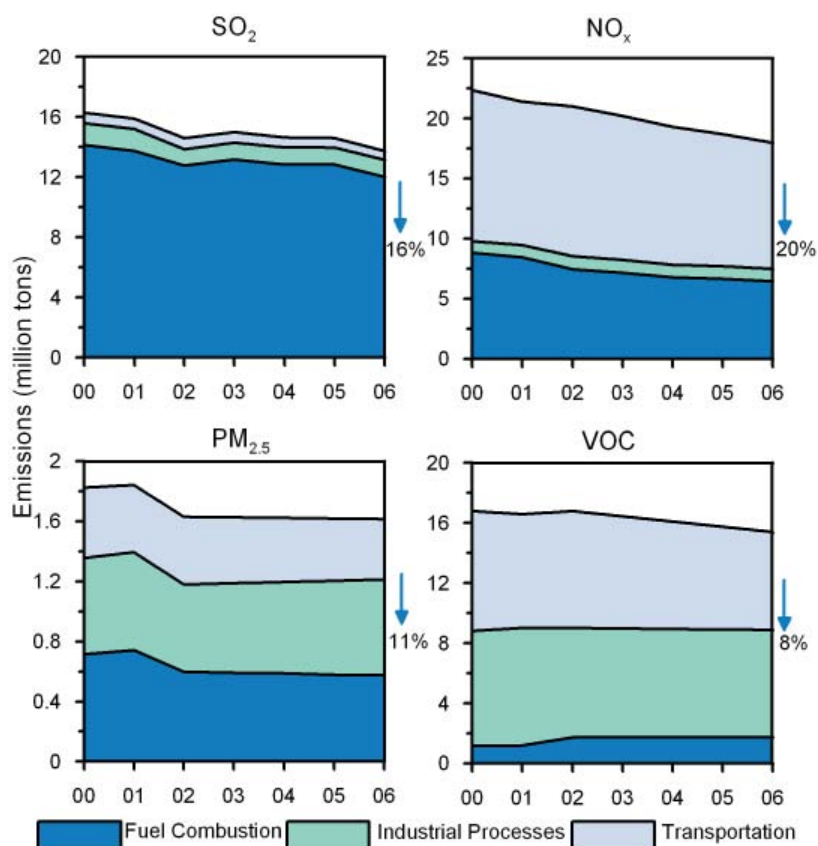


Figure 16. Number of days reaching Unhealthy for Sensitive Groups for $PM_{2.5}$ on the AQI for 2001-2005 (average) vs. 2006.



TRENDS IN $PM_{2.5}$ -FORMING EMISSIONS

Nationally, between 2000 and 2006, SO₂, NO_x, VOC, and directly emitted PM_{2.5} emissions decreased by 16, 20, 8, and 11 percent, respectively, as shown in Figure 17. The contribution of wildfires is not shown here. In fire-conductive years, up to 20 percent of direct PM_{2.5} emissions may be from wildfires; normally wildfire emissions are closer to 4 percent.

Figure 17. National trends in annual direct $PM_{2.5}$ and $PM_{2.5}$ -forming emissions, 2000-2006.

WEATHER INFLUENCE ON PM_{2.5}

Weather plays an important role in the formation of PM_{2.5} (see “Seasonal Influences” below). Figure 18 shows PM_{2.5} trends before and after adjusting for weather at selected sites. PM_{2.5} concentrations decreased 16 percent from 2000 through 2006. When the influence of weather is removed, the effect of changes in emissions on air quality is easier to see, and

PM_{2.5} shows an 11 percent decrease from 2000 through 2006. The observed PM_{2.5} levels in 2005 are lower after removing the influence of weather. Without the influence of weather, the underlying national trend in PM_{2.5} shows a moderate decline over the past several years and is more consistent with national trends in emissions.

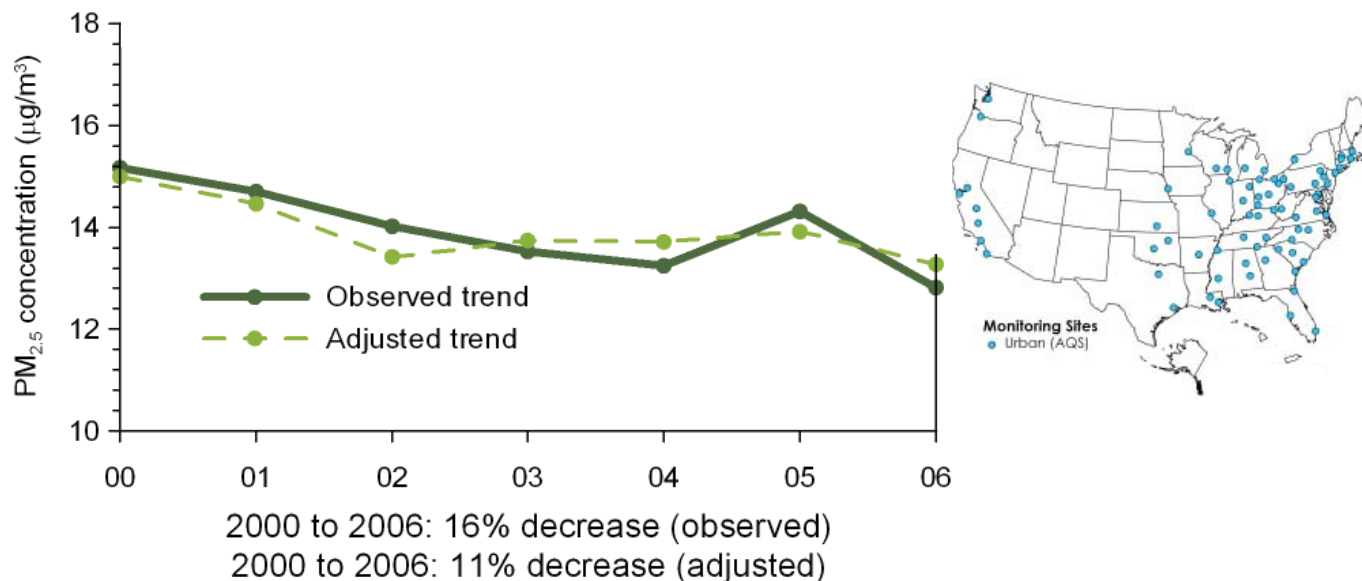
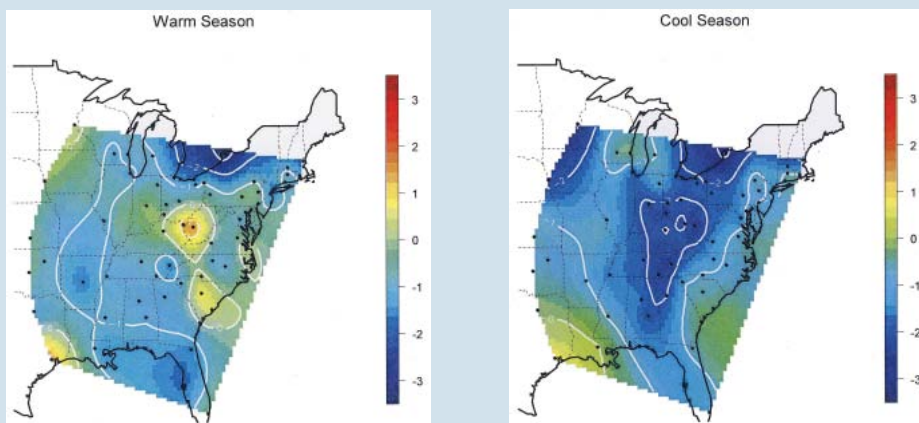


Figure 18. Trends in annual average PM_{2.5} concentrations, before and after adjusting for weather, and the location of urban monitoring sites used in the average.

Note: Meteorological adjustment is done on a site-by-site basis, with each of the 72 selected sites shown in this map representing an urban area.

Seasonal Influences on PM_{2.5}

Emissions sources and the composition of PM_{2.5} differ by season. For example, in cool months the greater demand for home or office heating (e.g., use of wood stoves or oil furnaces) creates more direct PM_{2.5} emissions, while in the warm months, weather conditions more conducive to PM_{2.5} formation create more secondary PM_{2.5}. To better understand weather influences on annual PM_{2.5} concentrations, the data were partitioned into “warm” and “cool” seasons. A statistical model was used to remove the influence of weather, as shown here for the eastern U.S. between 2000 and 2006. For the warm season, PM_{2.5} concentrations generally decreased (shown in blue) in the East except for modest increases (shown by yellow, orange, or red) in Houston, Texas, West Virginia, and South Carolina. During the cool season, noticeable decreases occurred across much of the East.



Change in warm (April-September) and cool season (October-March) PM_{2.5} concentrations in $\mu\text{g}/\text{m}^3$ after removing the influence of weather, 2000-2001 (average) vs. 2005-2006 (average).

Note: Two-year averages were used to mitigate uncertainty in individual year estimates. Estimated changes for locations that are not near monitoring sites (dots on map) have the largest uncertainty. For PM_{2.5} speciation by season, visit http://epa.gov/ttnnaqs/standards/pm/data/pmstaffpaper_20051221.pdf (see Figures 2-23 and 2-24).

TRENDS IN PM_{2.5} COMPOSITION 2002-2006

PM_{2.5} is made up of several different chemical components. In urban areas, PM_{2.5} is primarily composed of sulfate, nitrate, organic carbon (OC), and, to a lesser degree, elemental carbon (EC) and crustal material. Figure 19 shows regional trends in the composition of PM_{2.5} from 2002 to 2006. Decreasing concentrations in southern California from 2002 to 2006 were largely the result of decreasing levels of nitrate; OC levels remained relatively unchanged and have been the largest component of PM_{2.5} in the region. The Southeast had little change in PM_{2.5} and its two major components—sulfate and OC—over the five-year period. The industrial Midwest and the Northeast showed decreasing concentrations, except for an increased amount of PM_{2.5} in 2005. In 2005, the industrial Midwest had a temporary increase in PM_{2.5} concentrations, mostly due to more nitrate and sulfate, which was caused by a colder-than-normal winter and a hotter-than-normal summer. The former conditions were more conducive to nitrate formation, while the latter conditions were more conducive to sulfate formation and also caused higher SO₂ emissions due to higher electrical demand.

Sources of Particle Pollution

Component	Sources
Sulfates	Power generation
Nitrates	Cars, trucks, and power generation
Elemental and organic carbon	Cars, trucks, heavy equipment, wildfires, waste burning, and vegetation
Crustal	Suspended soil and metallurgical operations

Note: Ammonia from sources such as fertilizer and animal feed operations contributes to the formation of sulfates and nitrates that exist in the air as ammonium sulfate and ammonium nitrate. For more information about fine particle sources, visit <http://www.epa.gov/air/airtrends/aqtrnd04/pm.html>.

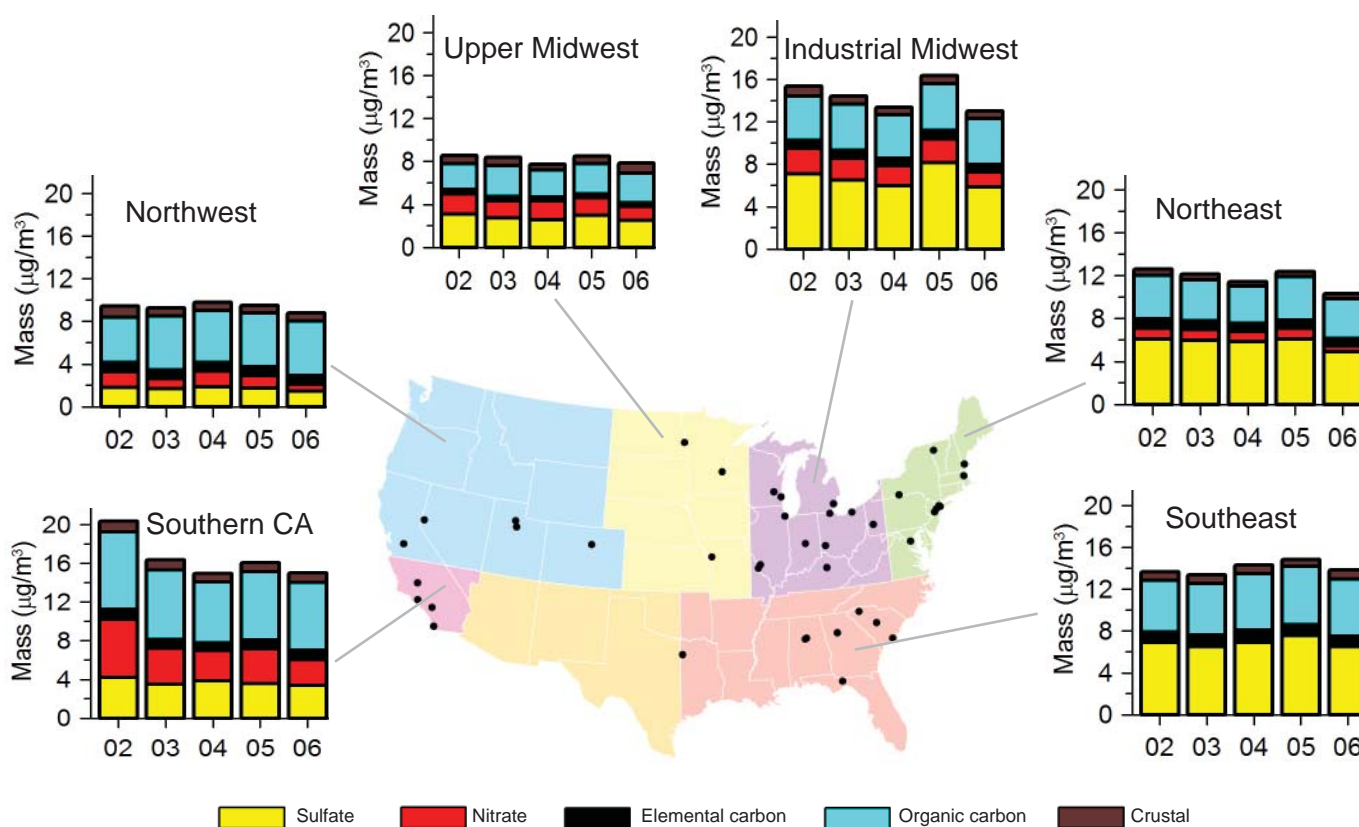


Figure 19. Regional trends in annual PM_{2.5} composition in µg/m³, 2002-2006.

Note: This figure is based on 41 monitoring locations with the most complete data from the national chemical speciation network for 2002-2006. There were no sites with complete data in the Southwest. These components are presented in terms of their mass as they might have been measured by the PM_{2.5} Federal Reference Method (FRM). To characterize these trends, ambient nitrate measurements, and associated ammonium, were adjusted to reflect the lower amount retained on FRM filters. Particle-bound water was included as a mass enhancement to measured sulfate, ammonium, and adjusted nitrate. Organic carbon mass was derived by material balance between measured PM_{2.5} and the other components.

TRENDS IN PM₁₀ CONCENTRATIONS

Between 1990 and 2006, PM₁₀ concentrations decreased 30 percent, as shown in Figure 20. The largest decreases were in Spokane, Wash., and Klamath Falls, Ore. Forty-three sites had an increase of more than 5 $\mu\text{g}/\text{m}^3$. The largest increases were in Houston, Texas; Las Cruces, N.M.; Nogales, Ariz.; Salt Lake City, Utah, and areas of Colorado. Figure 21 shows that in 2006 the highest concentrations were located in Illinois and the Southwest, including parts of California, Nevada, Arizona, New Mexico, and western Texas.

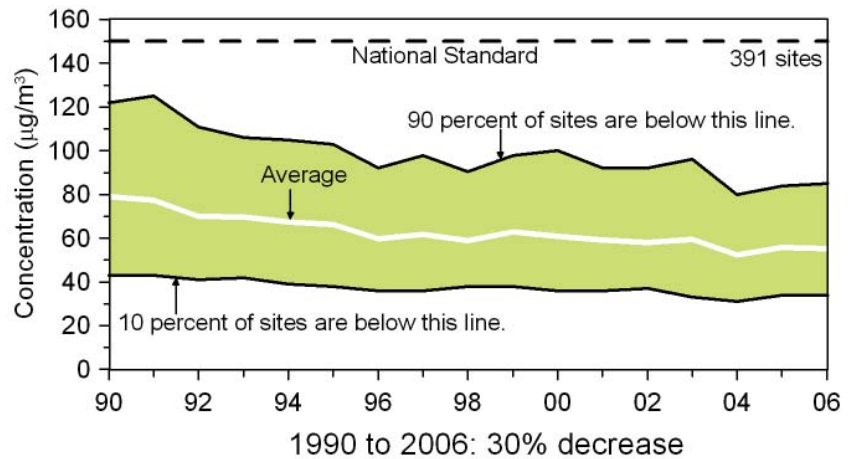


Figure 20. National PM₁₀ air quality trend, 1990-2006 (second maximum 24-hour concentration).

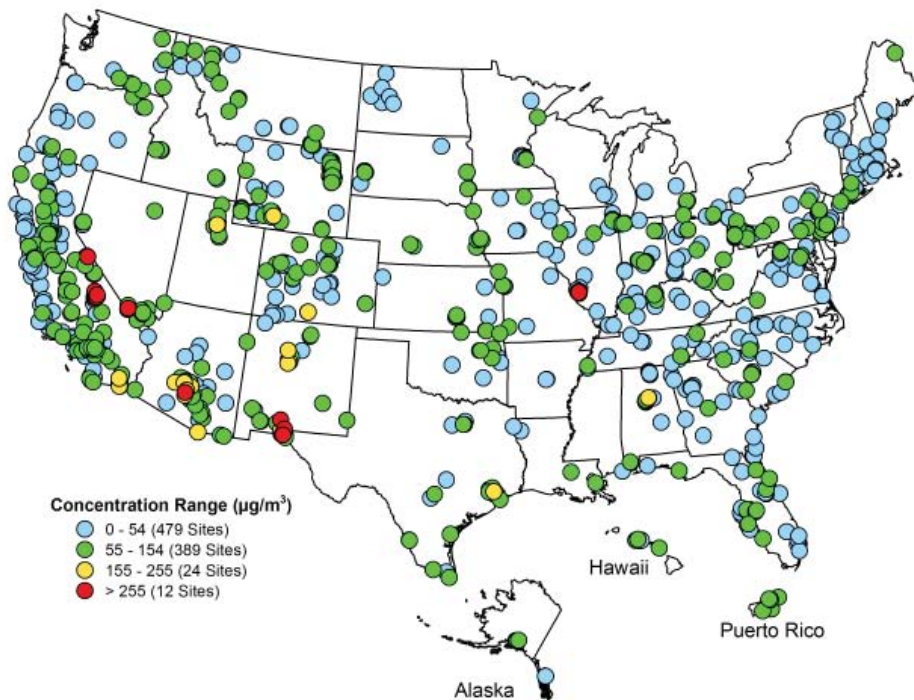


Figure 21. PM₁₀ concentrations in $\mu\text{g}/\text{m}^3$, 2006 (second maximum 24-hour concentration).

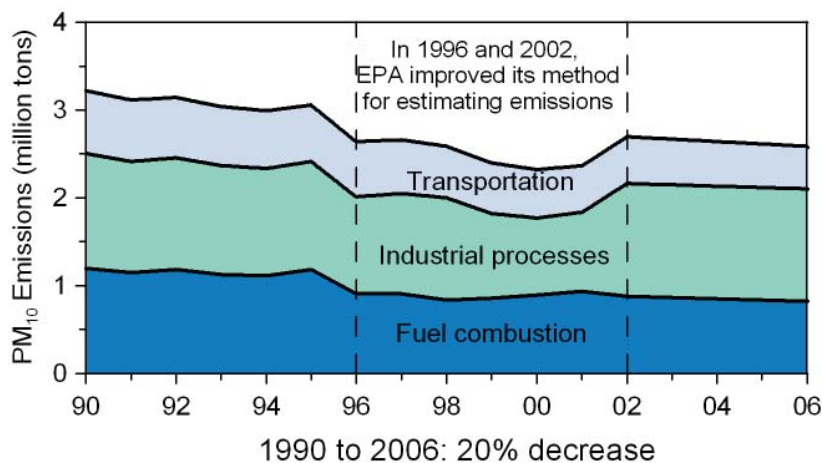


Figure 22. National trends in direct PM₁₀ emissions, 1990-2006.

TRENDS IN PM₁₀ EMISSIONS

Between 1990 and 2006, emissions of directly emitted PM₁₀ decreased 20 percent, as shown in Figure 22. Changes in how EPA compiled the national inventory over time may account for some differences.